ENSOL
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December 3, 2004 0068(B09)

Ms. Jaclynne Drummond
Solid Waste Section
Division of Waste Management
North Carolina Department of Environment and Natural Resources
Mail Service Center 1646
Raleigh, NC 27699-1646

RE: RESULTS OF PUMP TEST
DUNN-ERWIN MUNICIPAL SOLID WASTE LANDFILL, PERMIT 43-02
HARNETT COUNTY, NORTH CAROLINA

Dear Ms. Drummond:

On behalf of Harnett County and C.T. Clayton, Sr., PE, ENSOL, Inc. (ENSOL) is pleased to herewith provide you this letter report with results of the pump test performed November 17 and 18, 2004 in the contamination plume area downgradient of the currently active Construction and Demolition (C&D) landfill at the Dunn-Erwin Landfill facility. The pump test was another step in the evaluation of feasible corrective measures to be considered at this site in accordance with North Carolina Solid Waste Management Rule *15A N.C.A.C. 13 B, .1635*, in conjunction with an evaluation of possible permitting options for an extended C&D landfill permit in the downgradient area of the present landfill.

This report includes an introduction, pump test, analysis of results, and conclusions.

Should you have any questions or comments, please contact me at our address shown above or by e-mail at ***cporan@ensol.us***.

Sincerely,

ENSOL, Inc.

Chaim J. Poran, PhD, PE

cc. Jerry Blanchard (Harnett County)
C.T. Clayton, Sr., PE
Tyrus Clayton, PE (Draper Aden Associates)

/attachment

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1. INTRODUCTION

On October 12, 2004 Harnett County, via its consultants, submitted to the Solid Waste Section (SWS) a letter entitled "Work Plan for a Proposed Pump Test, Dunn-Erwin Municipal Solid Waste Landfill, Permit 43-02". The SWS responded with a few comments related to the proposed test by e-mail on October 20, 2004. These comments where addressed by Harnett County in an e-mail dated October 28, 2004 and in subsequent telephone conversation between Ms. Drummond of the SWS and Mr. Poran of ENSOL. The SWS then issued a letter approving the pump test on November 5, 2004.

The purpose of the pump test was to provide better understanding of the following main issues:

- Representative composite permeability in the uppermost aquifer within the estimated boundaries of the contaminant plume area
- Representative radii of influence and drawdown for pumping in the uppermost aquifer within the contaminant plume area

The pump test was performed on November 17 and 18, 2004, as follows.

2. PUMP TEST

2.1 Equipment

The following equipment was used for the pump test:

- Pumps: Proactive SS Mega-Typhoon Pump and Controller; Redi-Flo2 Submersible Pump and Controller; and Solinst Model 410 Peristaltic Pump
- Three (3) Groundwater level probes model Heron Dipper-T
- Self-contained 500 gallon tank with dedicated pump Sunbelt Rentals Model WT 540 to store the pump effluent
- Tubing, valves, 50 gallon plastic container
- Stopwatch
- Graduated cylinders: 1,000 and 2,000 ml
- Decontamination materials (Liqui-Nox Soap), rinsing water and plastic gloves

2.2 Pump Test Procedure

a. On November 9, 2004, a few days prior to the pump test four temporary piezometers were installed for the pump test. These one-inch (1") diameter piezometers were installed in the uppermost aquifer by Regional Probing Services, Inc. (RPS) using a Geoprobe®. For each of the two pumping

locations, MW-9 and MW-10, two such piezometers were installed within 10 to 50 feet downgradient. The locations of these piezometers are shown in Figure 1 as PZT-9-1, PZT-9-2, PZT-10-1, and PZT-10-2, respectively, with their elevation data provided in Table 1. The well logs of MW-9 and MW-10 were used to evaluate the installation of PZT-9-1 and PZT-10-1. Geoprobe® continuous samples were used to obtain data for the boring logs for PZT-9-2 and PZT-10-2, shown in Figure 2a and 2b, respectively. The four temporary piezometers will be properly abandoned in the near future. Photos taken during the pump test are shown in Figure 3.

b. Just before the test, static groundwater levels were measured in the nearby downgradient compliance wells (MWs), piezometers (PZs), observation wells (GP-xx-Ws, where "xx" is their respective number), and the temporary piezometers (PZTs) according to their locations shown in Figure 1. Generally, groundwater levels just before the pump test days were about average for the site. The following points were included in the pre-test groundwater level measurements:

MWs: 6, 7B, 9, and 10
PZs: 41S, 46S and 46D
GP-xx-Ws: 24, 25, 27, 28, 30, 31, 33, 34, 35, 36, and 38
PZTs: 9-1, 9-2, 10-1, and 10-2

c. The pump test was first started by pumping from monitoring well MW-10. Slug test results from this well performed in March 2001 showed a representative permeability of 3×10^{-6} cm/s for this well. However, using the Proactive SS Mega-Typhoon Pump and Controller, it was impossible to establish equilibrium flow conditions since the well was not recharging even at the lowest possible pumping rate for this pump, less than 1 gallon per hour (gph). At that time, after measuring a very slow recovery rate, the testing at MW-10 was aborted for 24 hours to allow well recovery before it could be retried with a low-flow peristaltic pump. Groundwater measurements at the two nearest monitoring points of PZT-10-1 and PZT-10-2 showed no change in levels compared to pre-test conditions, indicating the limited impact of the well drawdown. During the test, three dedicated groundwater level probes were used at MW-10, PZT-10-1, and PZT-10-2, respectively. Therefore, no decontamination was necessary until after the test.

d. The pump test was then started from MW-9 using the Proactive SS Mega-Typhoon Pump and Controller. Slug test results from this well performed in March 2001 showed a representative permeability of 8.6×10^{-4} cm/s for this well. Table 1a shows the summary of measured results. After a lengthy, systematic testing of pump settings and their resulting flow conditions equilibrium flow conditions were obtained. Then, data were recorded in intervals of 5 to 10 minutes after flow and drawdown equilibrium was reached for each interval. It became immediately evident that only the nearby temporary piezometer PZT-9-1 (located 10 feet away) was measurably affected by the pumping being. During the test, three dedicated groundwater level probes were used at MW-9, PZT-9-1, and PZT-9-2, respectively. No

groundwater level effect was observed at other more remote monitoring points including PZT-9-2 located 50 feet downgradient. This procedure was repeated in MW-9 on the next day, November 18, 2004 with a higher capacity Redi-Flo2 Submersible Pump and Controller where equilibrium was reached at a pumping rate of about 100 gph as shown in Table 1a. While higher pumping rates were evaluated, up to about 200 gph, it was not possible to maintain equilibrium at flow rates significantly higher than 100 gph.

e. On November 18, 2004, after MW-10 had fully recovered, the pump test was retried at that location by using a low-flow Solinst Model 410 Peristaltic Pump. After a lengthy, systematic testing of pump setting and its resulting flow conditions, equilibrium flow conditions were reached. Generally, equilibrium was reached at a very low pumping rate of about 1.5 gph and data were recorded in intervals of 5 to 15 minutes. Groundwater level measurements at the monitoring point of PZT-10-1 showed only a slight effect, indicating that the drawdown radius is limited to about 10 feet. No groundwater level effect was observed at other more remote monitoring points including PZT-10-2 located 50 feet downgradient. Again, during this test, three dedicated groundwater level probes were used at MW-10, PZT-10-1, and PZT-10-2, respectively.

f. All pumps and groundwater level probes were thoroughly decontaminated between applications in different monitoring wells, piezometers, or observation wells.

g. Pumped effluent from the pump test was collected into a trailer mounted plastic tank. After completion of the test the trailer was towed to the onsite MSW transfer station where the effluent was discharged into the leachate collection/wash down water tanks using the trailer's dedicated pump. This water will be collected by Harnett County and transferred to the local waste water treatment facility.

3. DATA ANALYSIS

3.1 Evaluation of Drawdown Radii

As shown in Table 1, equilibrium flow conditions reached during the pump test at MW-9 indicate that the monitoring point of PZT-9-1 was likely located inside and near the edge of the drawdown affected area indicating an apparent drawdown radius of slightly more than 10 feet but likely not more than 15 feet (based on results of simplified parametric evaluation). However, equilibrium flow conditions the pump test at MW-10 show that the monitoring point of PZT-10-1 was likely located just at the edge of the drawdown affected area indicating an apparent drawdown radius of just about 10 feet.

3.2 Representative Permeability Results

It was apparent during the pump test that the drawdown effect radius was about 10 feet at equilibrium conditions that were reached after experimenting with pumping rates and drawdown levels at the well being pumped. Therefore, to estimate the composite permeability corresponding to these pumping conditions, a simplified drawdown condition was assumed similar to what is shown in Figure 4 for an unconfined surficial aquifer overlying a confining layer. These conditions may be representative of the uppermost aquifer in the downgradient area MW-9 and MW-10 at the landfill. A simplified equation that may be used to estimate a representative composite permeability for the affected drawdown area in equilibrium flow conditions is as follows:

$$k_{mean} = \frac{Q_w \log_e \left(\frac{r}{r_w} \right)}{\pi \left(h^2 - h_w{}^2 \right)}$$

Where: Q_w = equilibrium pumping rate
k_{mean} = representative composite permeability of the aquifer
r = distance from pump location
r_w = radius of well being pumped
h_w = equilibrium drawn-down water level in the well being pumped
h = drawn-down water level at radius r from the pump

The above simplified equation was used to evaluate apparent permeability. The results of this evaluation are summarized below.

Pumping Location	**MW-9**	**MW-10**
Equilibrium Flow Rate Range (gph)	13 - 109	~ 1.5
Equilibrium Drawdown Range at Pumping Location (feet)	0.1 – 2.0	0.6 – 2.2
Apparent approximate Drawdown Radius Range (feet)	10	10 - 15
(a) Estimated Composite Permeability (cm/s)	1.3×10^{-5}	2.5×10^{-7}
(b) Slug Test Permeability Result from March 2001 (cm/s)	8.6×10^{-4}	3×10^{-6}
Order of Magnitude Ratio of Slug Test to Pump Test Permeability values (b)/(a)	1.8	1.1

4. CONCLUSIONS

a. The proposed pump test provided valuable data to be used in the evaluation of feasible corrective measures to be considered at this site in accordance with North Carolina Solid Waste Management Rule *15A N.C.A.C. 13 B .1635.*

b. Apparent equilibrium flow conditions were achieved during the pump test when pumping out of the two-inch (2") diameter monitoring wells at flow rate ranges of 13-109 and 0.6-2.2 gallons per hour, at MW-9 and MW-10, respectively.

c. It was evaluated that drawdown radii range of 10-15 at MW-9 and about 10 feet at MW-10 occurred during the pump test at equilibrium flow conditions indicated in Item *b* above.

d. Apparent flow conditions in the uppermost aquifer vary greatly in the contamination plume area, typical to surficial Middendorf Formation sediments. Evaluation of pump test results show that likely composite permeability in the uppermost aquifer could be around 1.5×10^{-5} cm/s in the vicinity of MW-9, and significantly lower, around 3×10^{-7} cm/s, in the vicinity of MW-10.

e. The composite permeability results obtained from evaluation of pump test data are generally between one and two orders of magnitude lower than results obtained from slug tests performed at MW-9 and MW-10 after wells were installed in March 2001. This trend could be explained in this site by the clayey sand deposits apparent in the downgradient area of these wells as observed in the assessment report of August 2003.

f. The semi-permeable (SEP) and impervious (IMP) type soils could be more prevalent around MW-9 and MW-10, respectively. This could explain why the representative permeability value of MW-9 is about two (2) orders of magnitude more pervious than the representative permeability value at MW-10.

g. Representative permeability value for MW-9 obtained from the pump test results is in the same order of magnitude, but about three times lower than the SEP permeability value used in the 2003 assessment, 1.5×10^{-5} and 5×10^{-5} cm/s, respectively.

h. Representative permeability value for MW-10 obtained from the pump test results is low, only about three times more pervious than the IMP permeability value used in the 2003 assessment, 2.5×10^{-7} and 1×10^{-7} cm/s, respectively.

i. Finally, the results from this pump test further demonstrate that it will be very difficult to model groundwater flow in the contaminant plume area with acceptable certainty. The parametric range that may be associated with many pumping scenarios could impose serious difficulties in evaluating a feasible plan for corrective action at this site.

TABLES

TABLE 1a
PUMP TEST RESULTS AND ANALYSIS MW-9

			Screen Elevations		Groundwater Data		
Monitor Well	TOC Elevation	Ground Elevation	Upper	Lower	Ave	Range	Avg depth to water
MW9	219.43	217.17	202.17	187.17	193.6	3.4	23.6
PZT-9-1	220.08	216.73	201.73	186.73			
PZT-9-2	211.80	209.38	199.38	189.38			

Nov. 17, 2004

Monitor Well	From TOC	MSL	Time	1:15 PM	1:35 PM	1:40 PM	1:50 PM	2:00 PM	2:05 PM	2:10 PM	11/18 1:10 PM
			Q (gph)	9	10	13.3	19.3	115	105	102	109
MW9	25.49	193.94	From TOC (feet)	25.50	25.50	25.63	25.74	27.10	27.50	27.64	26.99
PZT-9-1	26.22	193.86		26.22	26.22	26.25	26.27	26.38	26.38	26.41	↑ 26.37
PZT-9-2	18.17	193.63		18.11	18.11	18.14	18.14	18.14	18.14	18.14	↓ 18.11
			MSL								
		6.77	MW-9	193.93	193.93	193.80	193.69	192.33	191.93	191.79	192.44
		-0.08	Delta	0.01	0.01	0.11	0.20	1.45	1.85	1.96	1.40
			PZT-9-1	193.86	193.86	193.83	193.81	193.70	193.70	193.67	193.71
			PZT-9-2	193.69	193.69	193.66	193.66	193.66	193.66	193.66	193.69

55 minutes
every 5-10 minutes

Nov. 18, 2004

Monitor Well	From TOC	MSL	Time	1:10PM	1:15 PM
			Q (gph)	109	200
MW9	25.47	193.96	From TOC (feet)	26.99	31.50
PZT-9-1	26.25	193.83		26.37	26.41
PZT-9-2	18.11	193.69		18.11	18.11
			MSL		
			MW-9	192.44	187.93
		-0.13	Delta	1.40	5.87
			PZT-9-1	193.71	193.67
			PZT-9-2	193.69	193.69

~ 5 minutes

SUMMARY ANALYSIS OF PERMEABILITY

r1= 1"
r2=10 ft.

Q (gph)	16.3	107.8
Hw (feet)	6.58	4.95
H (feet)	6.73	6.61
k (cm/s)	1.5E-05	1.0E-05
k (cm/s)	1.3E-05	
Slug test	0.00086	8.6×10^{-4}
OOM	1.8	

TABLE 1b
PUMP TEST RESULTS AND ANALYSIS MW-10

aborted

Monitor Well	TOC Elevation	Ground Elevation	Screen Elevations		Groundwater Data			Nov. 17, 2004	
			Upper	Lower	Ave	Range	Avg depth to water	From TOC	MSL
MW10	214.54	211.57	203.57	188.57	193.3	3.5	18.2	21.27	193.27
								Ho	4.70
PZT-10-1	213.90	211.13	201.13	186.13				19.90	194.00
PZT-10-2	211.18	208.00	198.00	183.00				18.54	192.64

Time	11:27		Recovery	
		DT=0	DT=4 min	DT=12 min
	25.60	25.60	25.48	25.38
	20.84			
	18.53			

Notes:
On 11-17-04 Test could not continue since the pump was inadequate and at lowest setting the well dried up and was slow to recharge.

restart

Monitor Well	TOC Elevation	Ground Elevation	Screen Elevations		Groundwater Data			Nov. 18, 2004	
			Upper	Lower	Ave	Range	Avg depth to water	From TOC	MSL
MW10	214.54	211.57	203.57	188.57	193.3	3.5	18.2	21.26	193.28
PZT-10-1	213.90	211.13	201.13	186.13				20.88	193.02
PZT-10-2	211.18	208.00	198.00	183.00				18.51	192.67

Notes:
1. On 11-18-04 test was performed with a low-flow peristaltic pump
2. The temporary piezometers were installed on 11-9-2004 and their data are below;

Time	3:05 PM	3:15 PM	3:25 PM	3:30 PM	3:50 PM	4:00 PM	4:10 PM
Q (gph)	1.7	1.7	1.5	1.74	1.45	1.48	1.42
From TOC (feet)	21.26	21.26	21.88	22.10	22.85	23.05	23.45
	20.88	20.88	20.89	20.89	20.89	20.91	20.92
	18.51	18.51	18.51	18.51	18.51	18.51	18.51
MSL							
MW-10	193.28	193.28	192.66	192.44	191.69	191.49	191.09
Delta	-0.26	-0.26	0.61	0.83	1.58	1.76	2.15
PZT-10-1	193.02	193.02	193.01	193.01	193.01	192.99	192.98
PZT-10-2	192.67	192.67	192.67	192.67	192.67	192.67	192.67

55 minutes

SUMMARY ANALYSIS FOR PERMEABILITY

Raw= 1"

R=10 ft.

Q (gph)	1.52
Hw (feet)	3.32
H (feet)	4.71
k (cm/s)	2.5E-07
Slug test	3.0E-06
OOM	1.1

does not look right

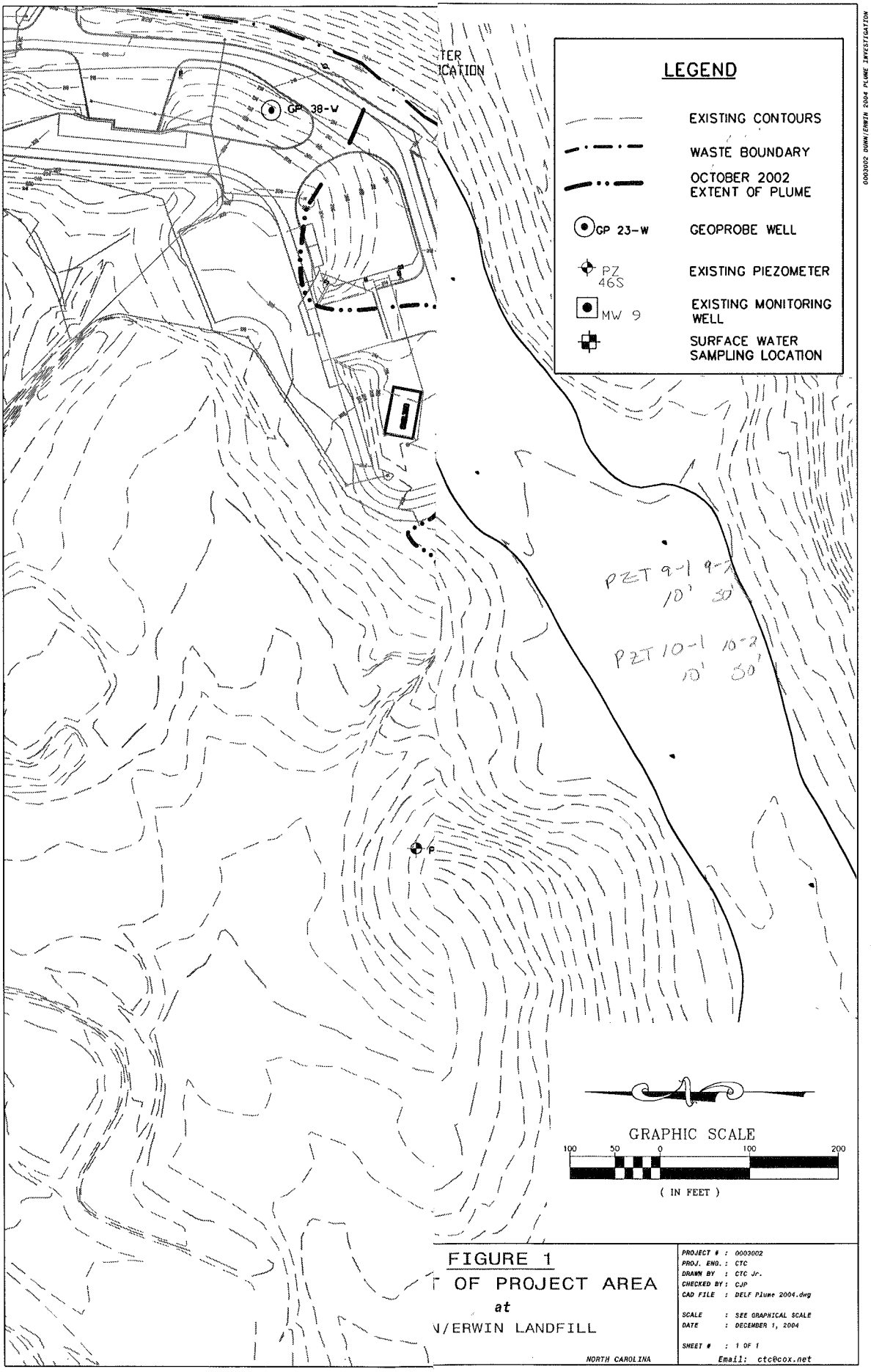
PZT-9-1 log not included in report

FIGURES

PZT-10-1 not included in report

Didn't use any other observation wells except 4 new PZTs installed

*provided limited data due to not using other observation wells


LEGEND
EXISTING CONTOURS
WASTE BOUNDARY
OCTOBER 2002 EXTENT OF PLUME
GP 23-W
GEOPROBE WELL
PZ 46S
EXISTING PIEZOMETER
MW 9
EXISTING MONITORING WELL
SURFACE WATER SAMPLING LOCATION
GP 38-V
PZT 9-1 9-2
10' 50'
PZT 10-1 10-2
10' 50'
GRAPHIC SCALE
100 50 0 100 200
(IN FEET)
FIGURE 1
T OF PROJECT AREA
at
N/ERWIN LANDFILL
NORTH CAROLINA
PROJECT # : 0003002
PROJ. ENG. : CTC
DRAWN BY : CTC Jr.
CHECKED BY : CJP
CAD FILE : DELF Plume 2004.dwg
SCALE : SEE GRAPHICAL SCALE
DATE : DECEMBER 1, 2004
SHEET # : 1 OF 1
Email: ctc@cox.net
0003002 DUNN/ERWIN 2004 PLUME INVESTIGATION

Draper Aden Associates
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Suite C-1
Angier, North Carolina 27501
Phone: (804) 264-2228
Fax: (804) 264-8773

Figure 2a
GeoProbe Boring Log
PZT- 9-2

Client: C. T. Clayton, Sr., P. E.
PO Box 12794, New Bern, NC 28561
Project: Dunn-Erwin Landfill Plume - Temp. Piezometer Installation
Date: 11/9/04
DAA No. RA00240-05

Logged By: CTC Jr.
Drill Type: GeoProbe
Drilled By: Regional Probing Services
Location: See Location Plan

Depth ft.	Elevation ft.	Legend	Description	USCS Symbol	Notes
0.0			Topsoil		
-1.0	208.0		SAND: Red-brown, coarse Sand w/ some small Gravel (Well-Graded SAND with Silt)	SW-SM	Ground Elevation = 209.48 TOC = 211.90 1" temporary piezometer set-screened from 199.48 to 189.48
-2.0					
-3.0					
-4.0	206.0		SAND: Red-yellow-brown, med. to coarse Sand. (Poorly Graded SAND with Silt) (with 0.5 to 1 inch gray-white sandy fat CLAY lenses from 3.5' to 4.5')	SP-SM	
-5.0					
-6.0	204.0				
-7.0					
-8.0	202.0				
-9.0			SAND: Brown-red, coarse Sand (Poorly-Graded SAND with some Silt)	SP-SM	
-10.0	200.0		CLAY: White-Grey, Silty CLAY with Red mottling	ML-CL SW-SM	
-11.0					
-12.0	198.0		SAND: Yellow-brown, Sand w/ some gravel (Well-Graded SAND with Silt)		Water @ 11.5' (Saturated Soils)
-13.0					
-14.0	196.0		SAND: Red, White, medium to fine Sand (Poorly-Grades SAND)	SP	
-15.0					
-16.0	194.0		SAND: Yellow-brown, Sand (Poorly-Graded SAND with Silt)	SP-SM	
-17.0					
-18.0	192.0		SAND: Red-white, medium to fine Sand (Poorly-Graded SAND)	SP	
-19.0					
	190.0				

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Date: 11/9/04
DAA No. RA00240-05

Logged By: CTC Jr.
Drill Type: GeoProbe
Drilled By: Regional Probing Services
Location: See Location Plan

Depth ft.	Elevation ft.	Legend	Description	USCS Symbol	Notes
-20.0			Terminated		Probe Terminated @ 20'
-21.0					

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Figure 2b
GeoProbe Boring Log
PZT- 10-2

Client: C. T. Clayton, Sr., P. E.
PO Box 12794, New Bern, NC 28561
Project: Dunn-Erwin Landfill Plume - Temp. Piezometer Installation
Date: 11/9/04
DAA No. RA00240-05

Logged By: CTC Jr.
Drill Type: GeoProbe
Drilled By: Regional Probing Services
Location: See Location Plan

Depth ft.	Elevation ft.	Legend	Description	USCS Symbol	Notes
0.0	208.0		Topsoil		Ground Elevation = 208.03
-1.0			SILT: Brown, Elastic Silt w/ coarse Sand w/ some small gravel	ML	TOC = 211.90
-2.0	206.0				1" temporary piezometer set-screened from 198.03 to 183.03
-3.0			SAND: Red-brown, coarse Sand w/ some gravel (Well-Graded SAND with Silt)	SW-SM	
-4.0	204.0		CLAY: Red-brown, Sandy CLAY	CL	
-5.0			SAND: Brown-yellow-red, coarse Sand w/ some gravel (Well-Graded SAND with Silt)	SW-SM	
-6.0	202.0				
-7.0					
-8.0	200.0				
-9.0					
-10.0	198.0				
-11.0			CLAY: Red, Grey, Yellow, mottled CLAY w/ Silt	ML-CL	
-12.0	196.0				
-13.0			SAND: Red-brown, coarse Sand (Poorly-Graded SAND with Silt)	SM	
				ML	
-14.0	194.0		SANDY SILT: Brown-Red-Grey Sandy SILT	SW	
-15.0			SAND: Red-white, medium to fine Sand (Poorly-Graded SAND)		
-16.0	192.0		GRAVEL: Grey, medium to large Gravel with some medium Sand	GP	
				SW-SC	Water @ 16.5' (Saturated Soils)
-17.0			SAND: Red-yellow-brown, medium coarse Sand (Well-Graded SAND with Clay)		
-18.0	190.0		SAND: Grey-yellow, very coarse Sand (Poorly-Graded SAND)	SP	
-19.0					

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Figure 2b
GeoProbe Boring Log
PZT- 10-2

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Logged By: CTC Jr.
Drill Type: GeoProbe
Drilled By: Regional Probing Services
Location: See Location Plan

Depth ft.	Elevation ft.	Legend	Description	USCS Symbol	Notes
-20.0	188.0				
-21.0					
-22.0	186.0				
-23.0			Fat CLAY: Brown, Grey, mottled Fat Clay (Fat CLAY with Sand)	CH	
-24.0	184.0		Terminated		Probe Terminated @ 24'
-25.0					

Figure 3.1 Pump Test Setup at Monitoring Well MW-10
(View east-northeast from piezometer PZT-10-2)

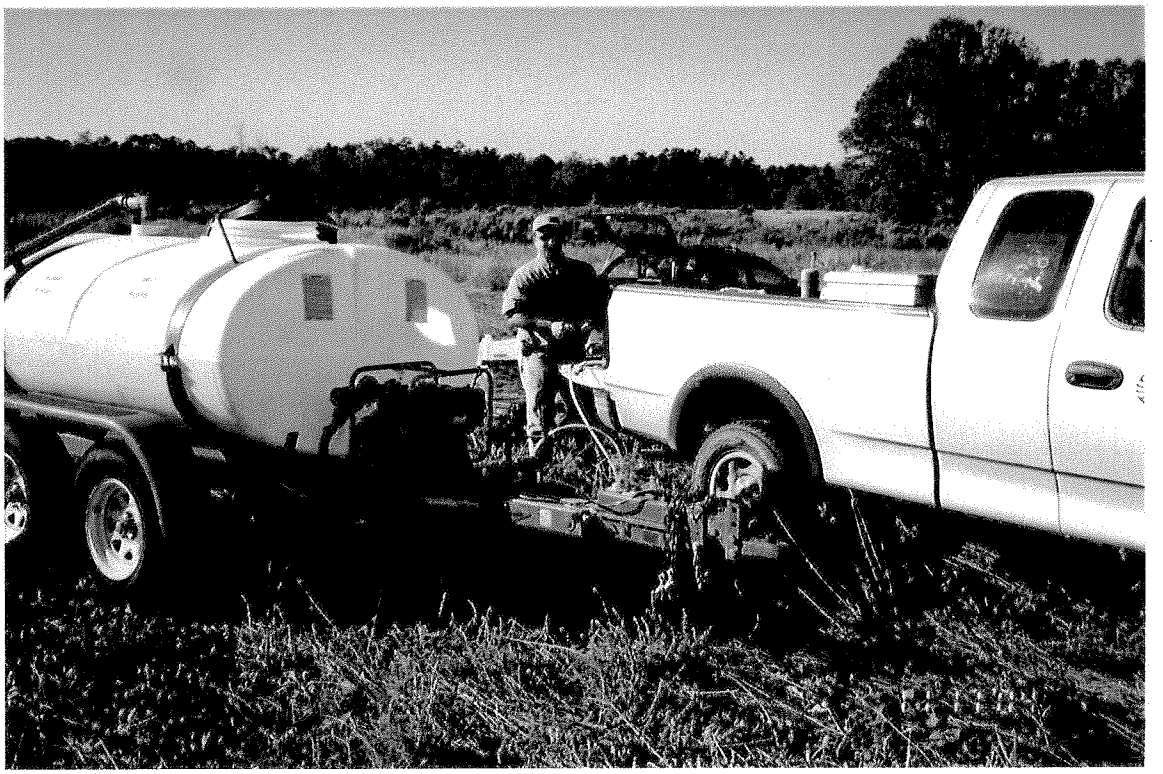

Figure 3.2 Storage Tank for Effluent Pumped Out During Pump Test
(View to southwest)

Figure 3.3 Very Low Flow Peristaltic Pump Used in Monitoring Well MW-10

Figure 3.4 Piping Setup for Flow Rare Measurements

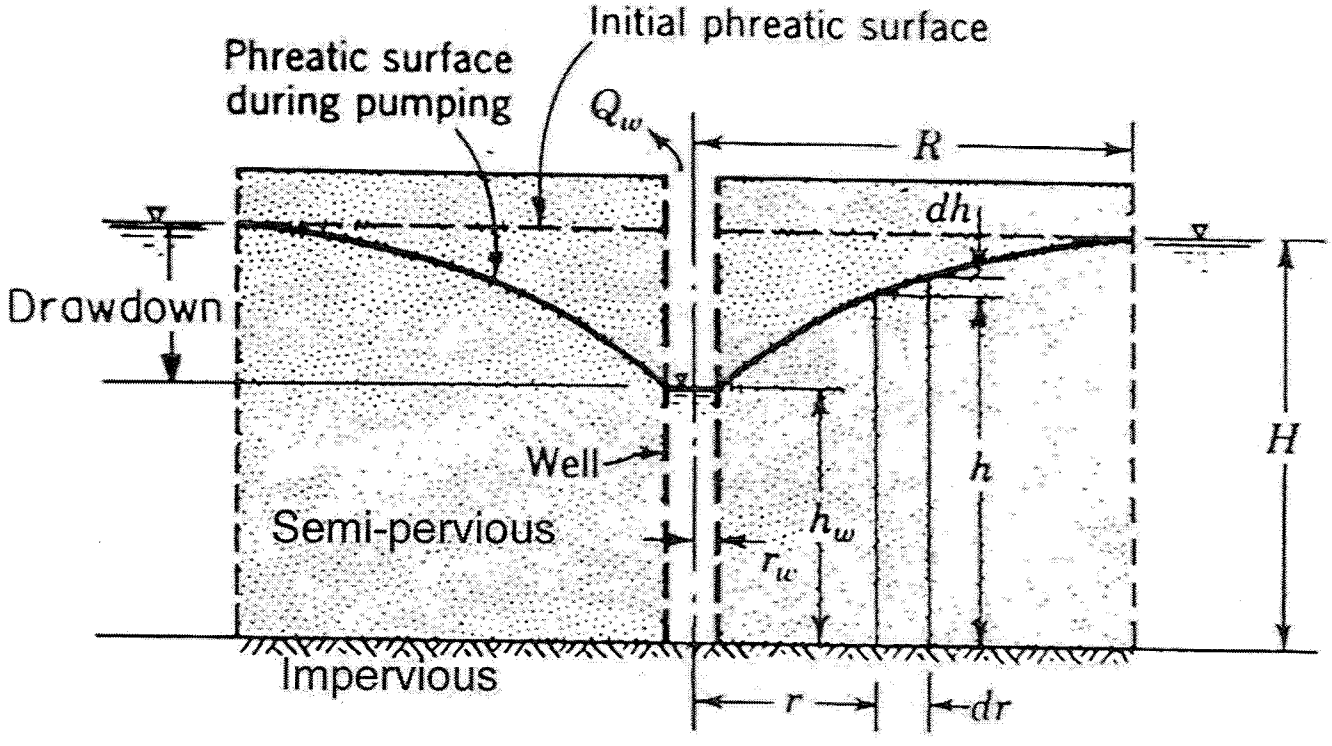

Figure 4. Drawdown Evaluation Parameters

(modified from Hunt, R.E., 1983, *Geotechnical Engineering Investigation Manual*, McGraw Hill, FIG. 8.33, p. 621)